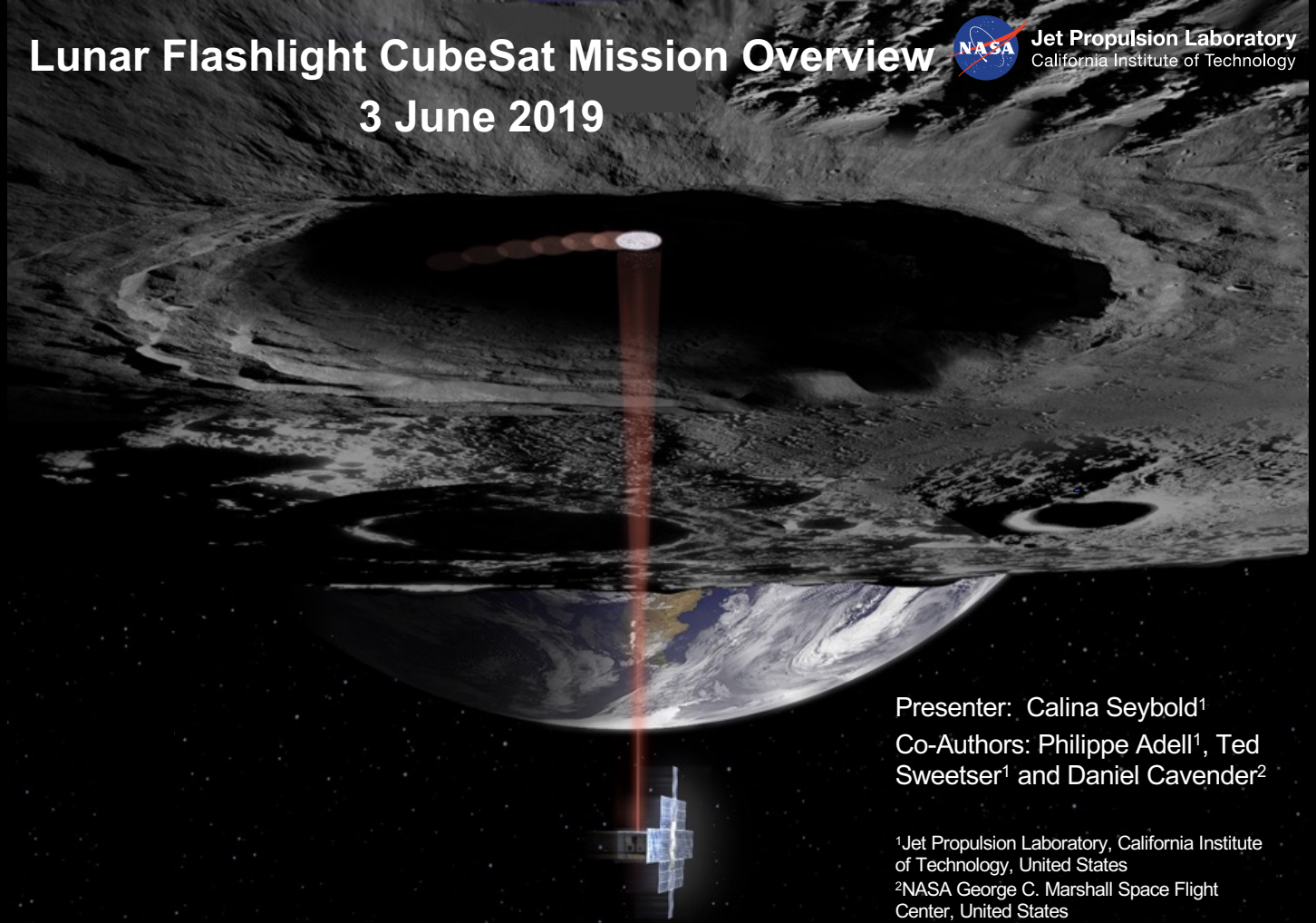
Lunar Flashlight CubeSat Mission Overview
3 June 2019



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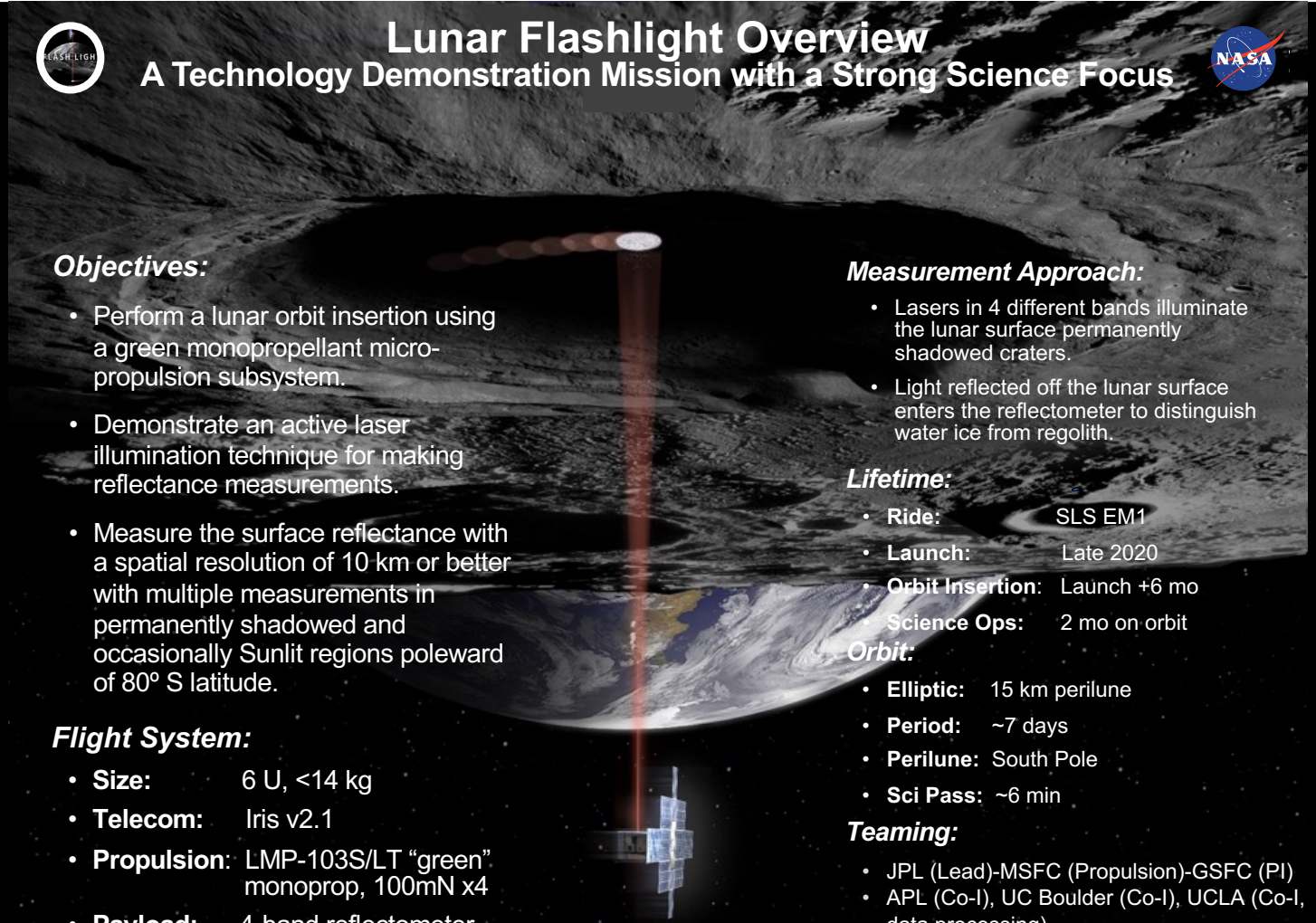
Lunar Flashlight Overview
A Technology Demonstration Mission with a Strong Science Focus



Objectives:

- Perform a lunar orbit insertion using a green monopropellant micro-propulsion subsystem.
- Demonstrate an active laser illumination technique for making reflectance measurements.
- Measure the surface reflectance with a spatial resolution of 10 km or better with multiple measurements in permanently shadowed and occasionally Sunlit regions poleward of 80º S latitude.

Flight System:

- **Size:** 6 U, <14 kg
- **Telecom:** Iris v2.1
- **Propulsion**: LMP-103S/LT "green" monoprop, 100mN x4
- **Payload:** 4-band reflectometer

Measurement Approach:

- Lasers in 4 different bands illuminate the lunar surface permanently shadowed craters.
- Light reflected off the lunar surface enters the reflectometer to distinguish water ice from regolith.

Lifetime:

- **Ride:** SLS EM1
- **Launch:** Late 2020
- **Orbit Insertion**: Launch +6 mo
- **Science Ops:** 2 mo on orbit

Orbit:

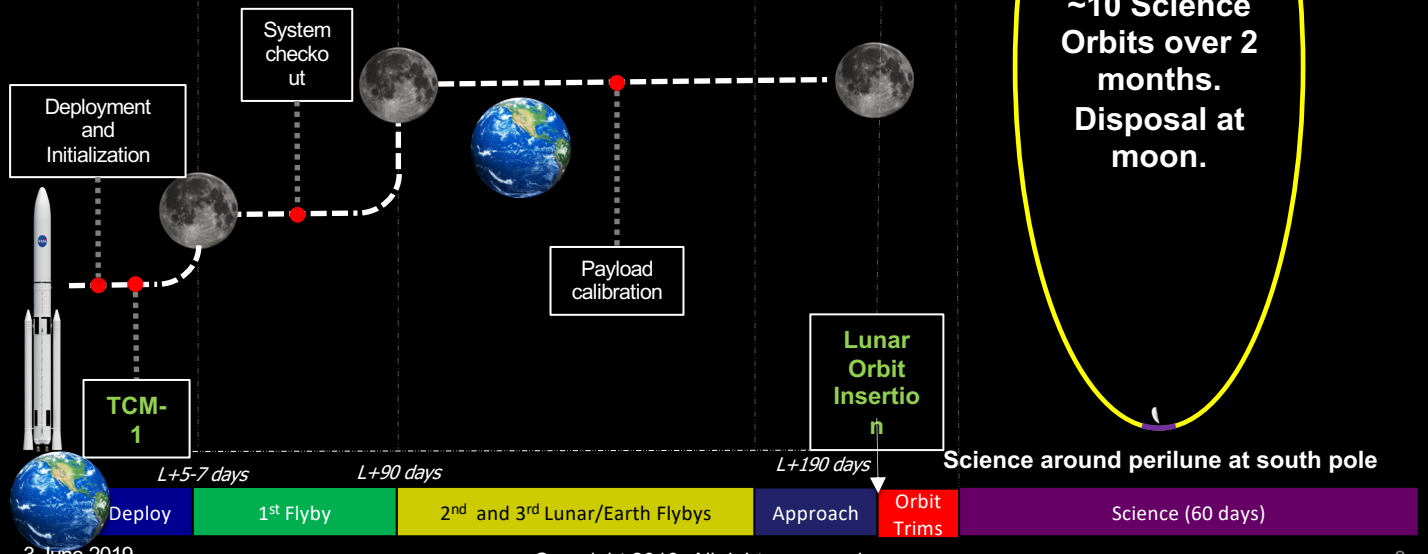
- **Elliptic:** 15 km perilune
- **Period:** ~7 days
- **Perilune:** South Pole
- **Sci Pass:** ~6 min

Teaming:

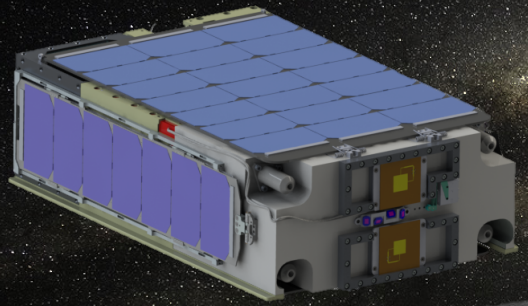
- JPL (Lead)-MSFC (Propulsion)-GSFC (PI)
- APL (Co-I), UC Boulder (Co-I), UCLA (Co-I, data processing)

Concept of Operations

- **Deployment from SLS at Bus Stop #1**
- **Low-energy transfer to polar lunar orbit insertion point required for Science Orbit**
  - TCM-1 avoids escape
  - 3 distant lunar flybys to achieve polar orbit with required sun geometry at moon
  - 3 distant Earth flybys: 40K, 35K, 90K km
- **Time of Flight: 190 days**
- **Insert into ~7 day polar orbit**
- **Total DV, including statistical, gravity loss, and orbit maintenance ~ 140 m/s**



Lunar Flashlight's Configurations



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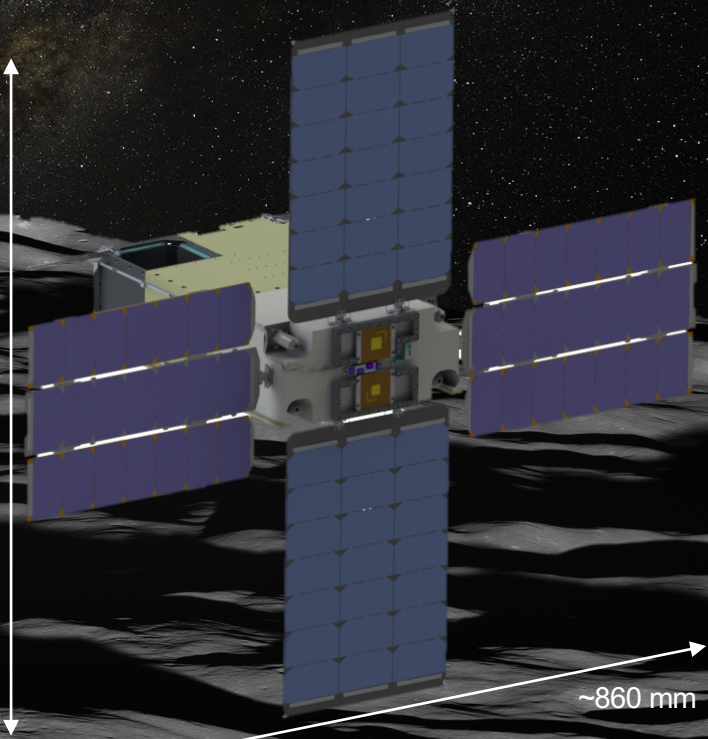
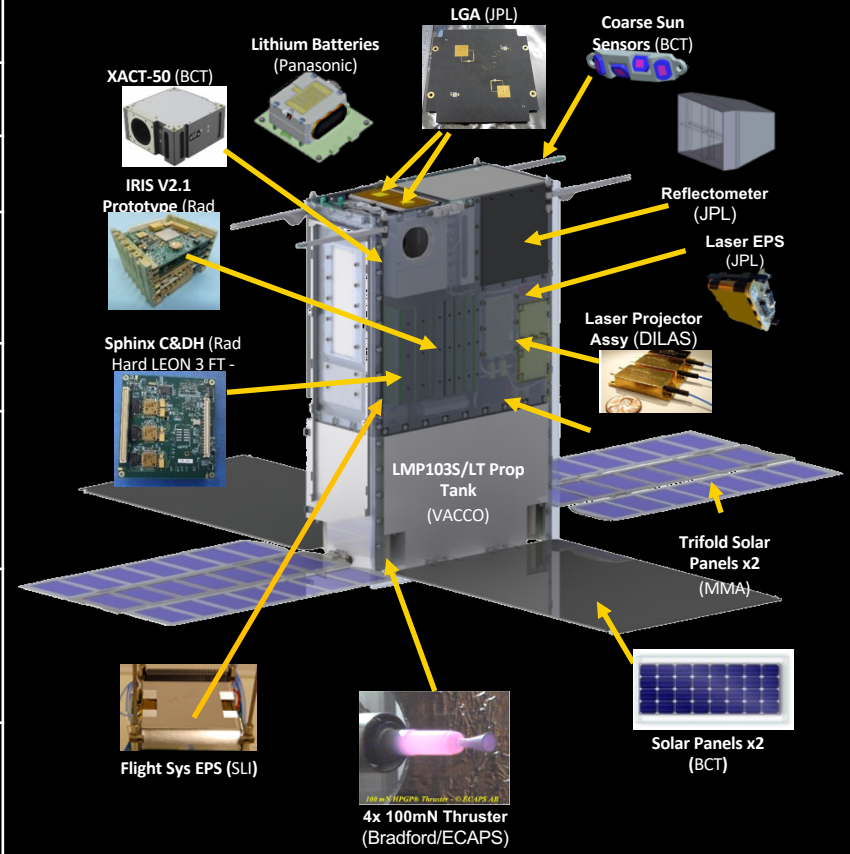


Flight

3 June 2019

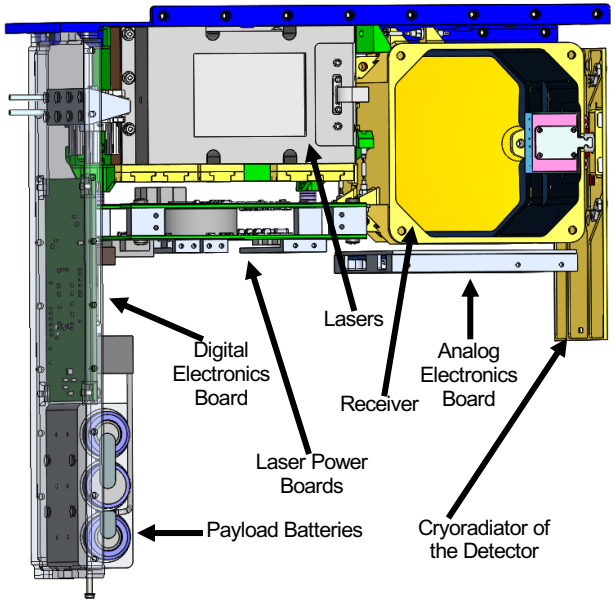
Flight System Overview

Lunar Flashlight	
Payload	• 4-band Laser Projector • Lunar Reflectometer Receiver
Mechanical & Structure	• 6U CubeSat form factor • ≤14 kg total launch mass
Propulsion	• ~250 m/s of delta-v capability • 4x100 mN thrusters • Utilizes LMP-103S/LT “green” monopropellant
Avionics	• Hybrid architecture of COTS and radiation tolerant components
Electrical Power System	• Flat-panel and tri-fold deployable solar arrays with UTJ GaAs cells • 18650 Li-ion battery cells • 9 -12.3 V unregulated, 5 V regulated
Telecom	• JPL Iris 2.1 X-Band Transponder; supports doppler, ranging, and D-DOR • INSPIRE-heritage low gain antennas (RX/TX)
Attitude Control System	• 50 mNm-s (x3) RWAs • Nano StarTracker, Coarse Sun Sensors & MEMS IMU for attitude determination

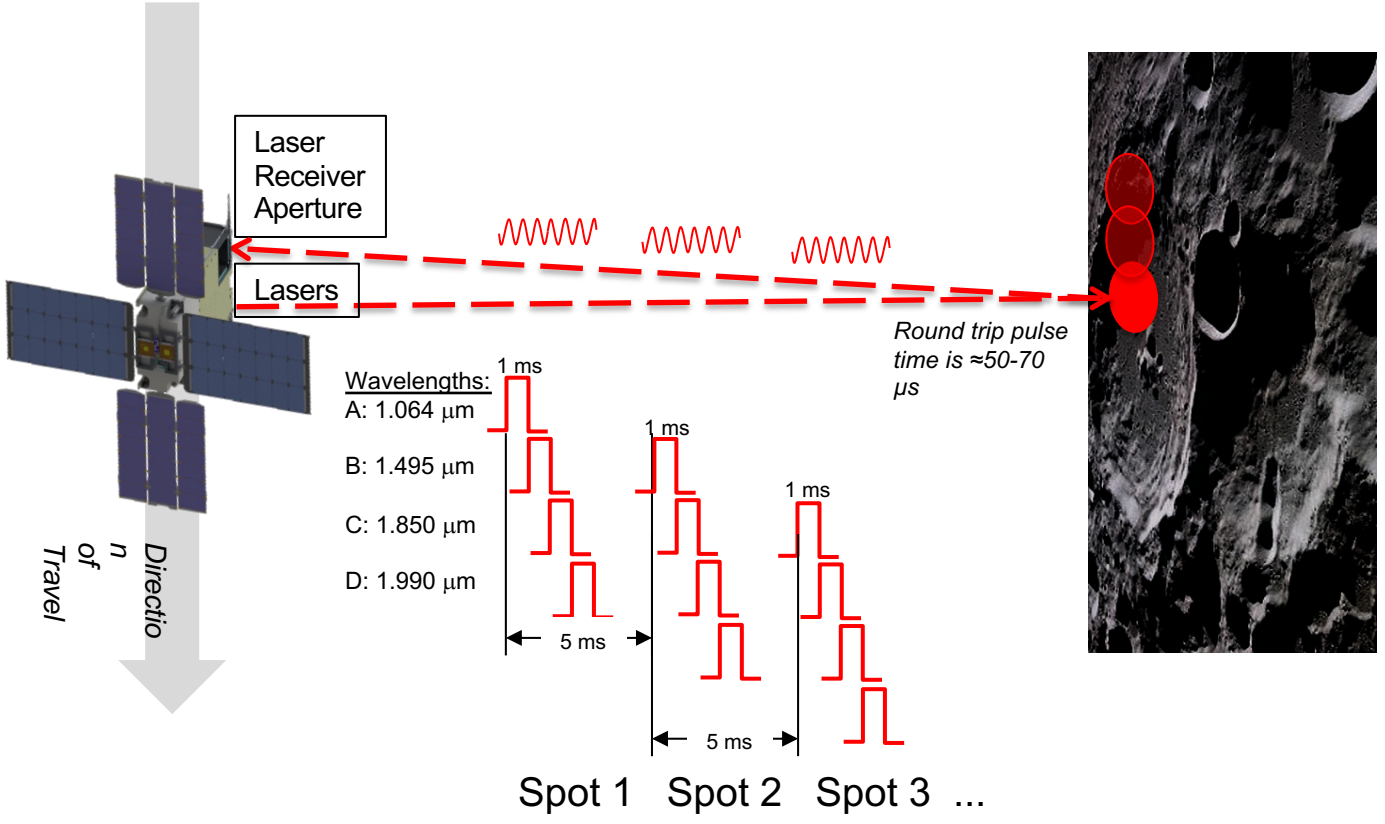


Technology Demonstration – Payload (1)
Description

- Occupies ~2U in a 6U flight system
- Optical receiver and laser emitter are supported on a very precise and stiff mechanical plate to facilitate alignment
- Receiver consists of a 70 mm off-axis parabolic mirror and a baffle assembly to shield the InGaAs detector from stray light
- Detector is cooled by an aluminum radiator mounted on the receiver body which radiates to deep space.
- Lasers are mounted on a phase change material box for thermal dissipation; laser power boards are also mounted to this structure.
- Three Li-ion 18650 battery cells, separate from the spacecraft battery cells, provide power for the lasers.



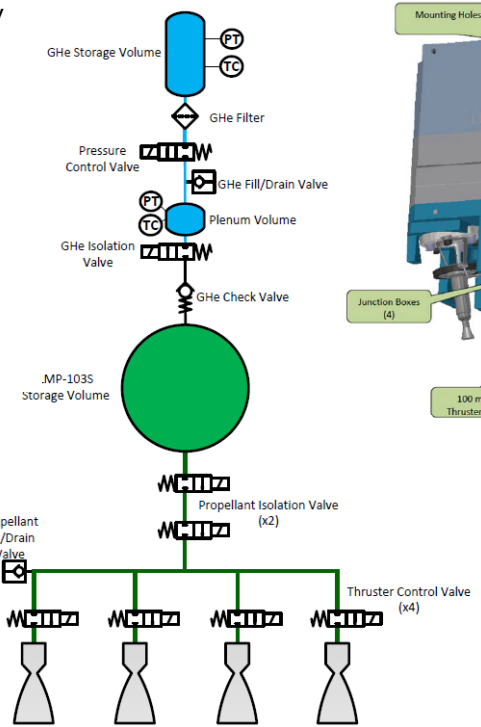
Technology Demonstration – Payload (2)
Payload Operations Concept

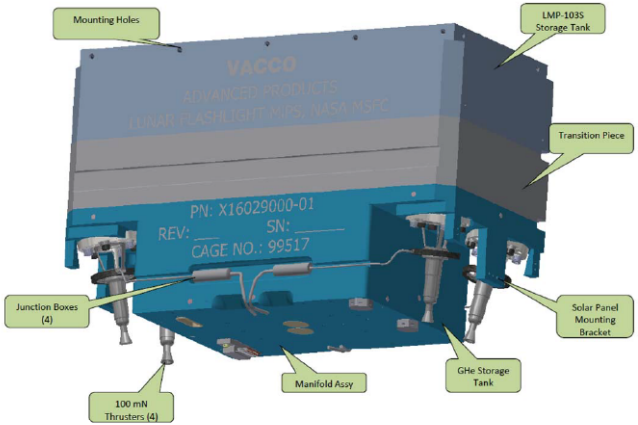


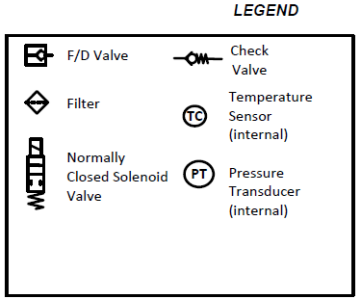
Technology Demonstration – Propulsion (1)
Micro-propulsion Subsystem

Self Contained Propulsion System:
- 4X 100mN thrusters, Canted 12°
- Provides Pitch, Yaw, Roll, & Delta-V
- All-Welded Titanium Alloy Construction
- Integrated Controller Electronics
- RS-422 Data bus Interface
- Minimum i-bit: ~5mN-sec

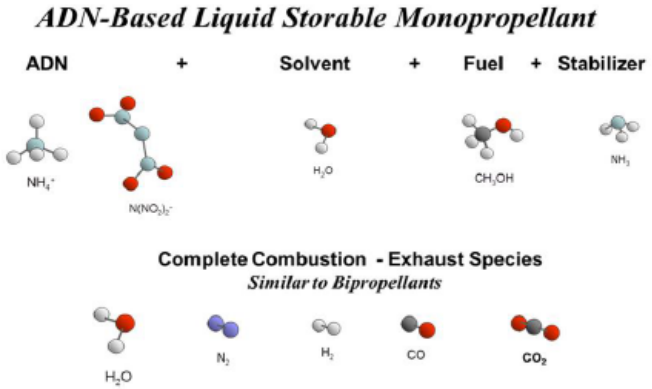
Range Safety Features:
- LMP-103S/LT, a “green” monoprop
- Dual-Fault Protection from Leakage
- Separate 5V & 12V Inputs
  - 5V for digital electronics
  - 12V for valves & heaters







- LMP-103S was developed in 2004 by ECAPS, at the time a subsidiary of the Swedish Space Corporation (SSC), as a high performing, reduced-toxicity monopropellant for spacecraft applications.
- LMP-103S is a storable liquid monopropellant blend based on Ammonium Dinitramide (ADN) blended with water, ammonia, and methanol.
  - Essentially a pre-mixed bipropellant, it is a highly energetic substance.
- Completed 5+ years of on-orbit demonstration aboard the PRISMA satellite, launched by the SSC in June 2010 out of Baikonur.



Summary and Project Status

- **Lunar Flashlight is:**
  - Demonstrating new technologies and addressing a strategic knowledge gap in a 6U CubeSat form factor
    - ”Green” propulsion subsystem with 100 mN thrusters to insert into lunar orbit
    - Laser reflectometer payload to measure and map %wt. of water ice
  - Advancing the next-generation of flight-proven technology
    - Iris v2.1 radio
    - Sphinx processor
  - A collaboration between several NASA centers and other institutions
    - Plus, custom, COTS, and in-house procurements
  - Finished with a successful RF compatibility test between our flight radio and the DSN
    - Included a successful end-to-end uplink and downlink test between our flight radio, the DSN, and the planned ground operations software
  - Accepting final hardware deliveries in preparation for system integration and test